THE CHANGING COASTLINE

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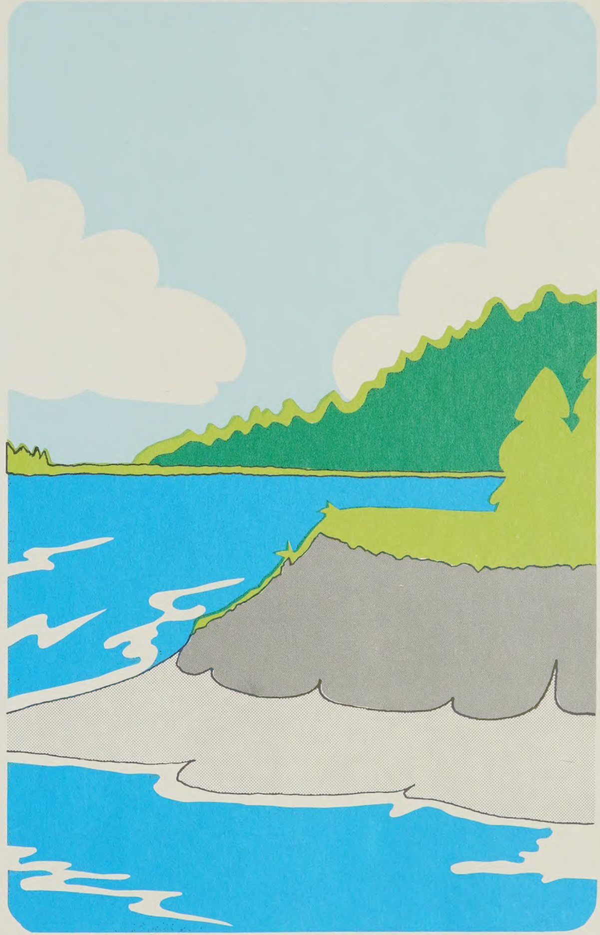
A look at shore erosion and protection

A guide for waterfront property owners



Preface

The shores and beaches of Canada are a vital natural resource. The growing demands on water-oriented recreation, expanding residential, commercial and industrial development, and the need for newer and larger port facilities have greatly increased both the use and importance of waterfront property. Yet, many of our most valuable shores are extremely prone to erosion and, if left unprotected or allowed to be developed without due regard to the forces of nature, may suffer rapid and extensive damage.

Historically, Public Works Canada has been associated with the study of shore erosion and has also constructed a wide variety of shore protection works. This activity has sprung from its involvement in the protection of Federal waterfront properties and its interest in assisting in the protection of shorelines against wave action created by commercial ships or the effects of Federal structures, such as breakwaters and jetties, on adjacent shorelines. Because of the increasing public concern over damage to shoreline property, Public Works Canada has prepared this publication to help waterfront property owners understand the changing character of the coastline and underlying shore processes. Where specific problems occur, waterfront property owners are well advised to seek expert advice to make detailed analysis and devise suitable remedial measures.

Prepared by Marine Directorate

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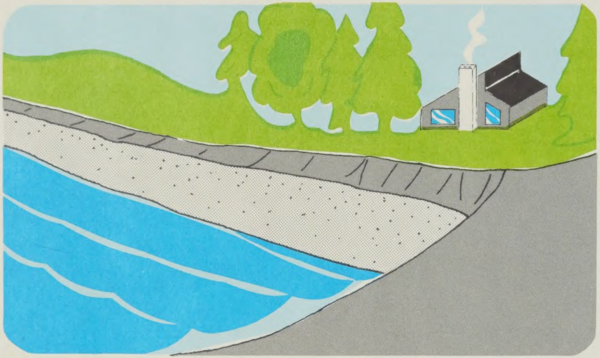
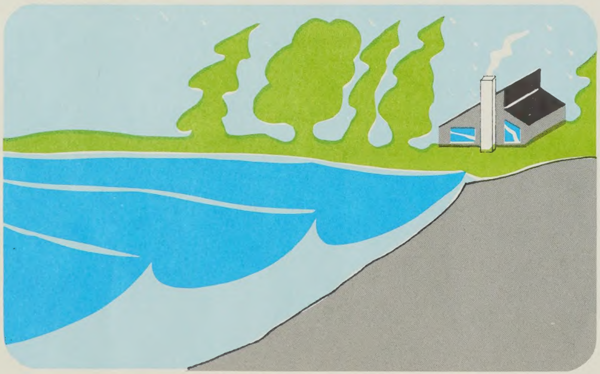
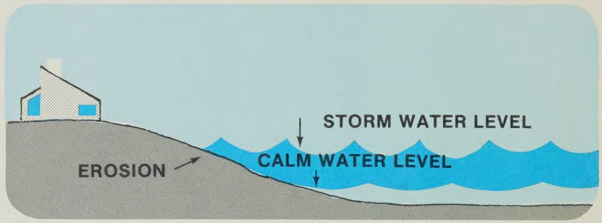
The Waterfront

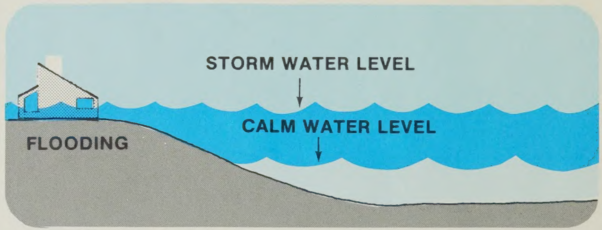
On a calm day, or even during a minor storm, a waterfront property may appear secure and impregnable. Yet,during a very severe storm, especially at high water or tide, rapid erosion, and on low coastal lands inundation and wave encroachment can occur causing severe damage.

The possibility of a "limited natural life" of a waterfront property, its vulnerability to serious damage by major or extreme storms or flooding, and the feasibility of its protection are very important considerations when buying, using or planning the development of this type of property.





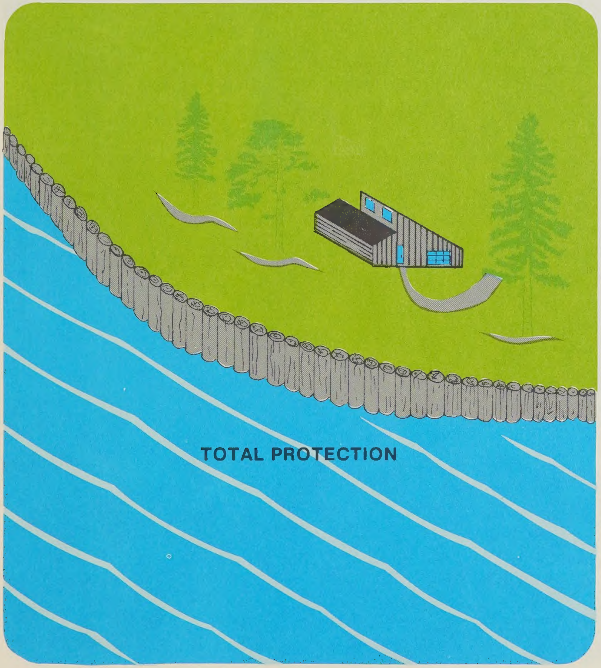




Since shorelines are formed in different soil formations and are exposed to different wind, current, wave, and water level regimes, the coastal process and the tendency to change vary considerably from place to place. Accordingly, the susceptibility of waterfront properties to erosion, inundation, wave encroachment damage or floods, as well as the feasibility of protecting them, greatly depends on their location.

On some sections of coastline, the natural tendency towards coastal change and the exposure to sea attack are such that the cost of shore protection could be uneconomical and, in some cases, permanent protection may be unattainable.

Nature has its own designs upon the shaping of the shoreline and its own ways of moderating the sea attack on the coast. Beaches are an excellent example of an effective natural shore defence. However, to continue to exist, they require a supply of sand — often provided from the gradual erosion of an adjacent shoreline or a cliff or bank behind them. Therefore, in densely developed areas over-protection of a shoreline may result in the depletion and even disappearance of beaches. These changes could lower the recreational value of the shore, increase erosion in the unprotected areas, and adversely affect existing shore protection works.



Awareness of excessive interference by man with the natural coastal process and possible long term adverse effects on coastlines, as a resource and recreational base, have prompted in recent years increased studies of the coastline problems in Canada by the Federal and Provincial governments and also the gradual development of guidelines for coastal zone management, mapping of hazardous coastal lands, and in some cases restrictions on waterfront use.

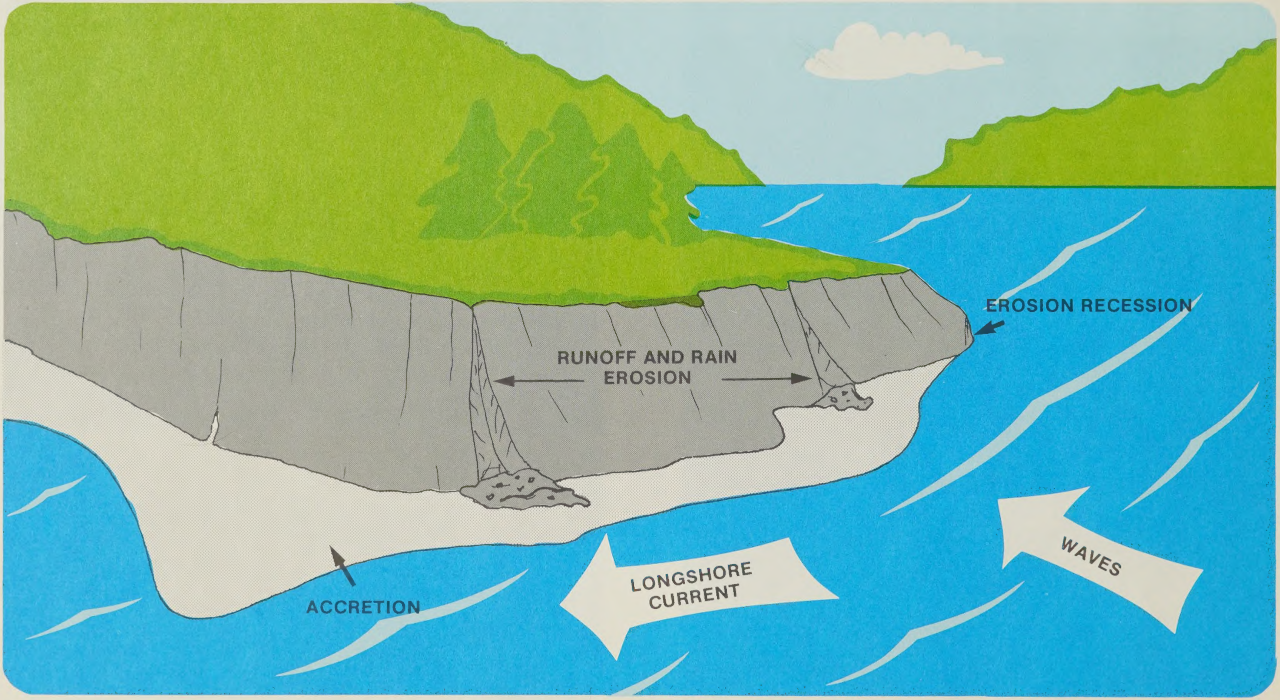
The Changing Coastline

The coastline, the boundary between land and water, is undergoing a continuous change of form and configuration under the action of natural forces.

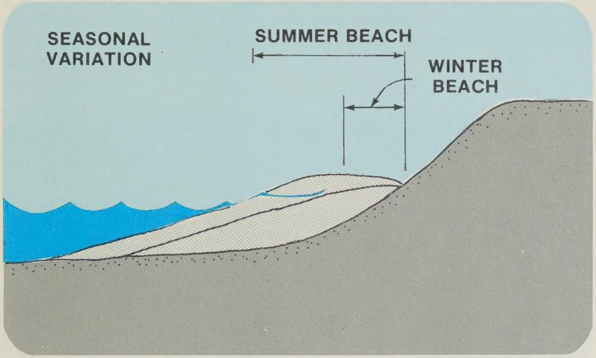
As a result of this natural process of coastal development, the boundary between land and water may undergo a shift forward in the case of an advancing shoreline (accretion) or landward in the case of a receding shoreline (erosion).

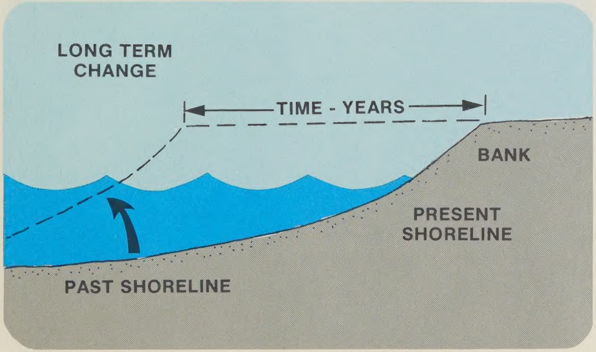
Depending on the nature of the coastline and the intensity of the natural forces acting on it, the process of coastal change can be slow or rapid.

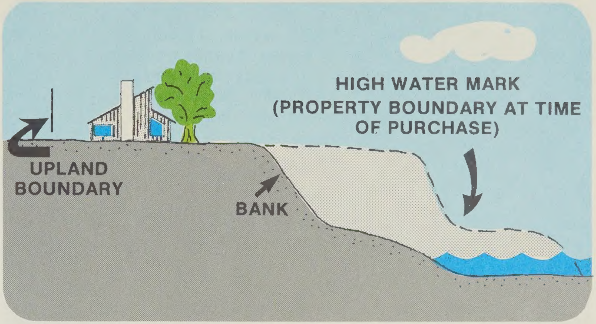
On hard rock shoreline, the changes may be so slow that they can only be detected when measured in geological time. On soft rock shoreline, the changes can be discerned within the time span of one to several generations, while on shores formed in unconsolidated materials (gravels, sands, silts and clays) significant changes can often take place even within the time span of one generation.

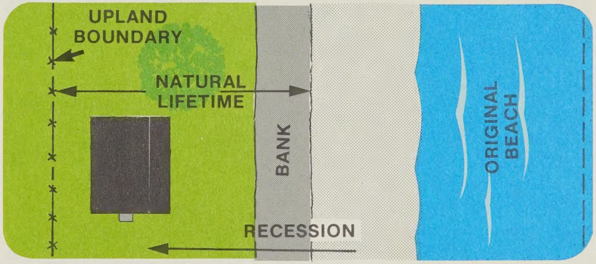


When speaking of coastline changes, a distinction must be made between long term trends and seasonal variations. For example, a beach width may be halved by fall and winter storms but may regenerate itself in the summer to its original width (seasonal variation). At the same time, the whole beach-bank profile may be gradually receding at an annual rate of a fraction of a metre to a few metres per year (long term trend).



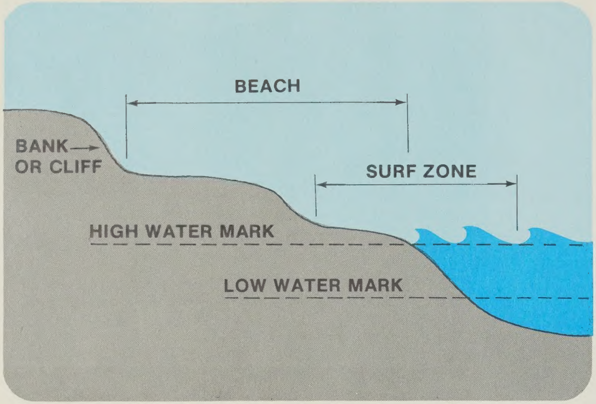






The land boundaries of waterfront properties, usually described by meets and bounds in deeds, are fixed lines in relation to upland properties and remain fixed. By contrast, the waterside boundary usually defined as the "water edge" or "ordinary high water mark" shifts with the coastline. As a result, the actual size of the property may be subject not only to seasonal changes but in the long term may expand if the shoreline advances (accretion) or diminish in size if the shoreline recedes (erosion). So, on eroding shorelines, unless erosion is arrested, often by costly protective works, the waterfront property could disappear with time when the water edge or high water mark reaches the original upland boundary of the property, thereby expiring its "natural life".

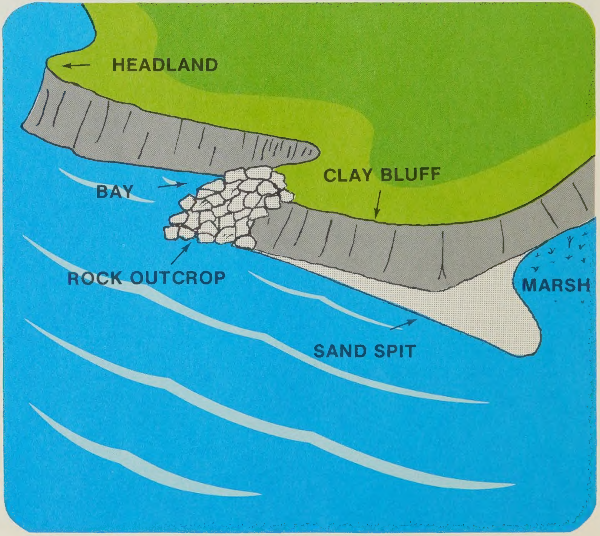
The main factor changing and shaping the shore is the action of the waves, particularly that of storm waves. The magnitude of the reshaping that can be caused by waves depends on the geometry and geology of the shore, changes in the water level and currents, winds, seepage, and surface run off, but it is the waves that make the coastal retreat continuous. Ice and frost also play a part in the shore development.



Geometry and Geology

The surf zone is the most active area of a shore because it is here that the waves spend most of their energy. If there is no beach or if it is too narrow, the bank or cliff can become a part of the surf zone and victim of wave attack.

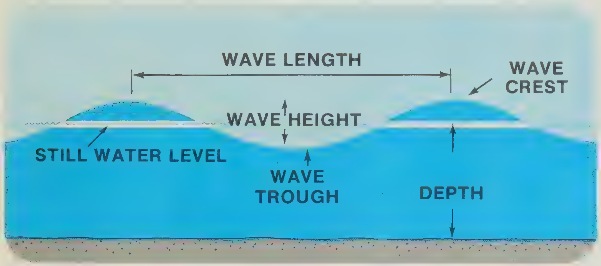
The shore modifications produced by any wave attack depend on the resistance of the shore to the wave forces. The resistance of a shore to changes, in turn, depends on the shore slope, material and whether the shore is located on a headland, in a bay, or along a straight coastline, and whether it is capable of developing and maintaining a stable beach form.



Waves

Generally, waves are defined by their height and length or period. Wave height is the vertical distance between the top of the crest and the bottom of the trough. Wave length is the horizontal distance between successive wave crests. Wave period is the time between successive crests (or troughs) passing a fixed point.

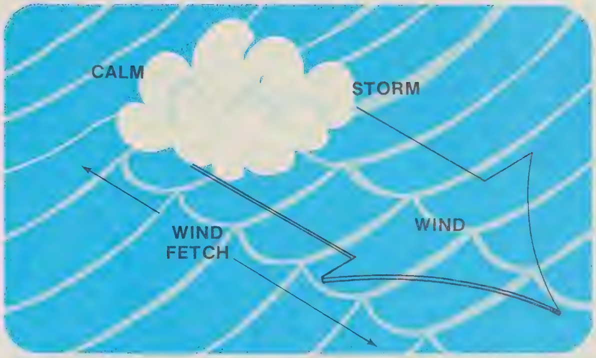
The height, length and period of a wave are determined by the distance the wind blows over water (fetch), the speed of the wind, the length of time the wind blows and the distance the wave travels after leaving the area in which it was generated. Since wind speed is not constant, the wind will simultaneously generate waves of many heights, lengths and periods, often superimposed on each other, resulting in a turbulent and confused water surface.



If the wind of a local storm blows towards the shore, the waves reach the shore in nearly the form in which they are generated. Under these conditions, the waves are steep: that is, the wave length is 10-20 times the wave height. Such waves are called storm waves and depending on their height, they have a high erosive capability.

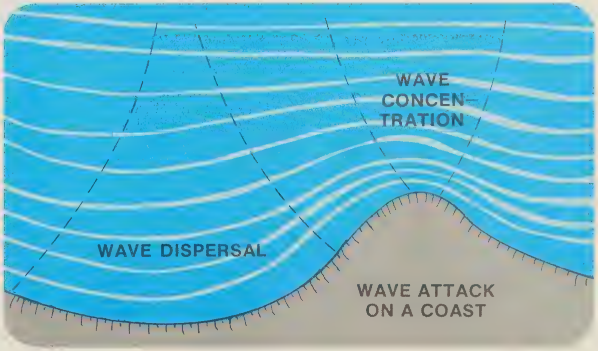
The waves that reach the beach are smaller than the storm waves in the open sea or lake.

When deep water waves enter the progressively shallower water of the nearshore zone,they start to "feel" the bottom. They turn towards the shore and become progressively shorter and more unstable. In a depth of water of 1 to 1-1/2 times their wave height,the waves break, lose part of their power and progress towards the shore as smaller waves only to break again nearer shore in shallower water and eventually on the beach. So,the maximum height of waves in the surf zone is governed by the depth of water.



Outside the surf zone, in the area where the waves "feel" the bottom, underwater topography may influence the distribution of wave energy reaching the shoreline. If the offshore slope is uniform and even, the wave attack along the shore will be fairly uniform. If the offshore bottom is irregular the wave attack, even within a short length of coast, may vary considerably.

Underwater valleys and bays tend to disperse the waves over a wider length of shore, while humps and ridges tend to focus the waves on a shorter stretch of shore.

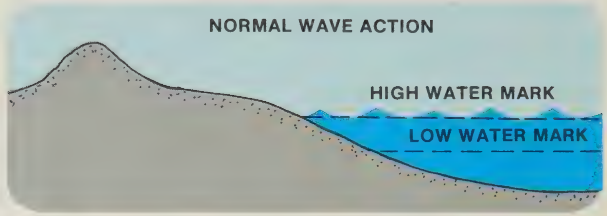


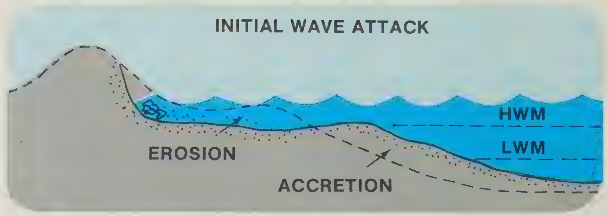
Wave Action

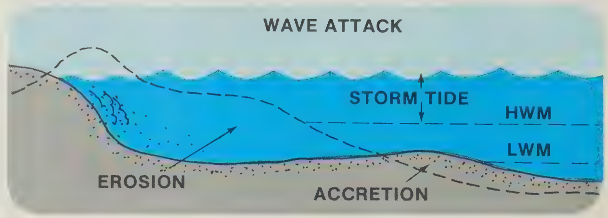
As waves travel from deep water towards shore, they reach a depth where water motion begins to affect the sediment on the bottom. As the depth decreases, the water motion along the bottom increases and at some point the waves begin to exert enough force to move bottom material (i.e. bed load transport). When the depth is further decreased, the force becomes stronger; material becomes agitated and suspended (i.e. suspended load transport); finer material is moved seawards; and coarser particles may migrate shorewards. Soon a depth is reached where the wave can no longer support itself and it breaks. On breaking, the wave travels as a flood of water, the swash carrying with it bottom material.

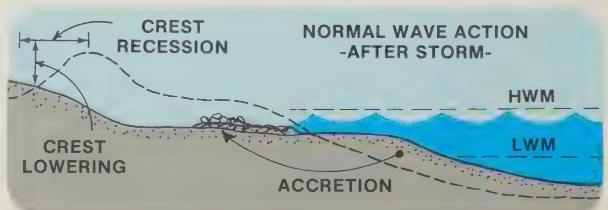
During storm conditions, several factors can combine to damage the shore. In a train of storm waves, the waves may have varying characteristics. They break at different depths, thereby widening the surf zone, resulting in a larger bed and suspended load transport area. They are also steeper and have a cutting action on the shore. The runback of each wave carries away more material than is brought shorewards by the run-up of the following wave. The result is shore erosion. If the shore waves are accompanied by currents and high water levels associated with storm surges and high tides, parts of the coast are inundated, submerged and removed.

Thus the shore migrates landwards. Some replenishment of material usually occurs from adjoining areas brought by longshore currents, littoral drift and from offshore material brought by sea swells, but often the damage can be permanent.



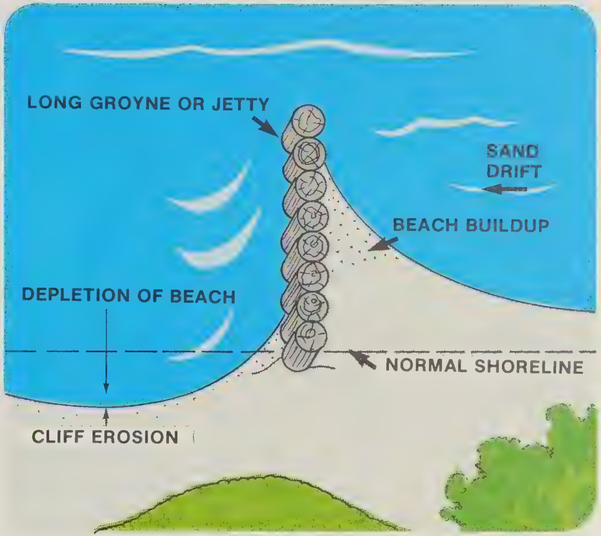






Beaches

Granular material, derived from bank erosion or brought by waves as littoral drift, may accumulate at the toe of the shore cliff to form a beach. If the beach is wide, it may prevent wave swash from reaching the bank thus protecting it fully from wave attack. Narrow beaches, while not fully protecting cliffs behind, greatly reduce wave attack and retard cliff erosion.



The sand on the beach is in constant motion under the influence of winds, waves and currents. To retain the beach effectiveness as a coastal defence, any material removed from it must be replenished by littoral drift from up coast. If the beach material supply source is upset or cut off, the beach will gradually diminish in size and its effectiveness as a sea defence will be lost.

Natural and Artificial Protection

The very existence of beaches demonstrates nature's ability not only to erode but also to protect. Apart from beaches, other natural protections exist on the coast. Learning from nature, man has devised equivalents of the natural protective forms. Some of these are given here with their function. The types more suitable for private individual shore protection are marked with an asterisk (*).

Natural Coastal Protection	Man-made Equivalent	What it does
Shore Rock	Sea Wall	Resists erosion by hardness of face.
Rock reef	Submerged bulkhead or breakwater	Forces larger waves to break on it, reduces wave access to shore, reduces wave attack in its shadow.
Rock island	Off-shore breakwater	As for rock reef.
Headland	Large breakwater perpendicular or at an angle to the shore	Provides anchor for a stable beach or a bay form.
Rock ledge or boulder ridge perpendicular to shore	Groynes *	Traps sand and encourages beach formation.
Low rock ledge or boulder formation parallel to shore	Beach sill or armoured berm *	Stabilizes bank toe. Reduces wave backrush effects and height of wave uprush.
Rock or boulder talus along the foot of shore cliff	Revetment *	Protects underlaying softer bank strata from wave action — resists erosion.
Cobble or boulder beach cover	Armoured beach, concrete block pavement or rock mattress. *	Protects lower beach and off-shore bed from erosion.
Bay Form	Artificial bays, multiple bays formed between artificial headlands, long high widely spaced groynes.	Changes the ratio of beach material stripping and deposition tendencies by waves. Allows for development of more stable beach with lower littoral supply.
Sea floor vegetation	Flexible mattresses	Reduces or prevents sea floor erosion, dampens waves reaching shore.
Sea surface vegetation	Floating breakwaters	Dampens waves reaching the shore.
Dune	Dyke, artificial dune	In extreme storms, forms barrier and prevents inundation of low coastal areas. Dunes provide reserve sand supply to fronting beaches.
Material transfer to shore by: - Wind drift, rivers, shore erosion, longshore littoral drift, sea bottom transfer - natural by-passing of drift at tidal inlets, river mouth and headlands	Artificial nourishment from land sources * Artificial nourishment from offshore sources. Mechanical by-passing of drift at littoral barriers.	Ensures continuity of supply of beach material, keeps the supply and loss of beach material in balance.

Certain natural coastal features such as rock, headlands, beach accretion etc., while stabilizing a section of the shore may cause undesirable changes, such as erosion in an adjacent section of the coast. For example, a headland may interfere with littoral transport — assisting in maintaining a stable beach on its up-drift side, but creating a deficiency of beach material on the down-drift side inducing rapid erosion. This erosion, in turn, may be the sole or principal source of beach material to a coastal section further down-drift helping to stabilize it.

The same phenomenon observed in nature may develop with man made shore protection. Artificial stabilization of one section of the shore may be contributing to the increased instability of another section.

Artificial shoreline "hardening" (shore protection and stabilization works), if done properly and with the full understanding of the coastal process, may moderate the overall losses, but it cannot eliminate entirely the recession process of the shoreline. Improperly done, it may, in the long run, do more harm than good and accelerate the coastal retreat.

The main causes of erosion by nature and man are listed here.

Causes of Erosion by Nature and by Man

Nature

- Rise in sea level.
- Protruding headlands, reefs and rocks causing downdrift erosion.
- Tidal entrances and river outlets causing interruption of littoral drift.
- Shoreline geometry causing rapid decrease of longshore drift.
- Natural blocking of river outlets carrying sediments to the shore by flood stage barriers, change of locations of outlets due to floods, erosion, tectonic movement, etc.
- Storm breaching of barrier beaches or radical changes in coastal features due to extreme storms that cause decrease of longshore drift quantity.

Man

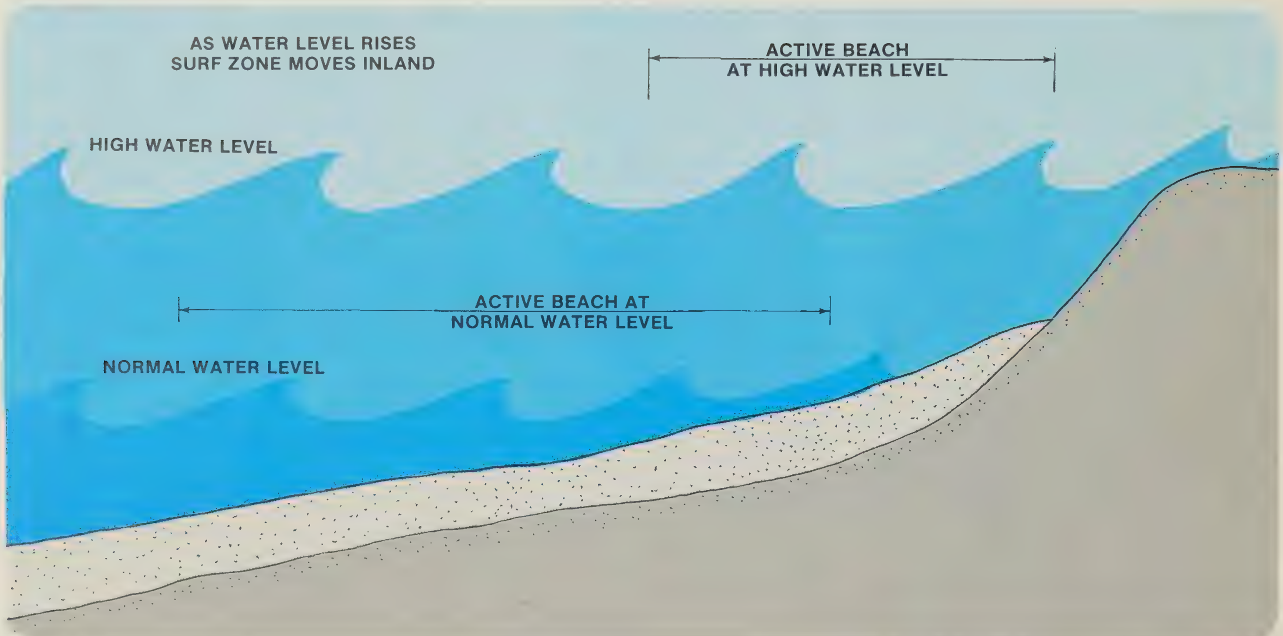
- Dams, dykes and other coastal structures causing rise of water levels and concentration of tides, storm surges or waves.
- Groynes, jetties and breakwaters causing interruptions of littoral drift and increasing down-drift erosion.
- Dredged navigation channels perpendicular or at an angle to the shore causing interruption of littoral drift.
- Fill protruding out of the shoreline to such extent that it changes radically local shoreline geometry and causes decrease of longshore transport.
- Damming rivers without providing material passing sluices, causing reduction of sediment supply to the shore.
- Irrigation and soil conservation projects decreasing the flow of water and sediment to shore.
- Stripping of surface vegetation causing increased seepage through shore cliff or higher surface runoff.
- Removal from beaches of large rocks, boulders, cobbles and sand.

Effect of Water Level on Erosion

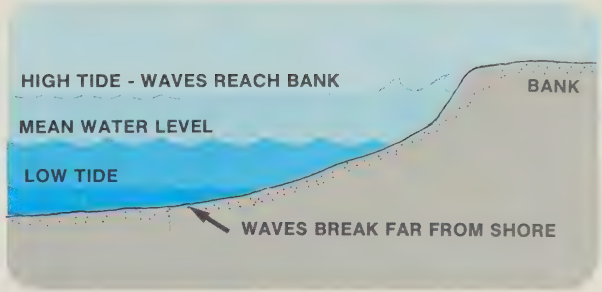
Water level fluctuations can have a considerable influence on shore erosion, primarily by bringing wave action to different parts of the shore.

On any coast, the average water level establishes the mean beach profile. When the water level is high, the beach is inundated. The surf zone moves inland and the effectiveness of the beach, as a defence against sea attack, is reduced as the waves penetrate further inland increasing erosion.

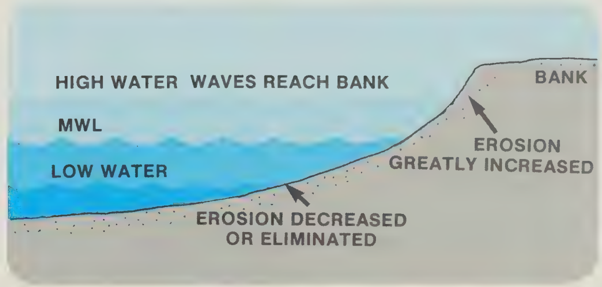
At low water levels, a wider beach is exposed. The surf zone moves seaward and waves may not reach the bank over the beach. Thus, erosion decreases or ceases altogether.



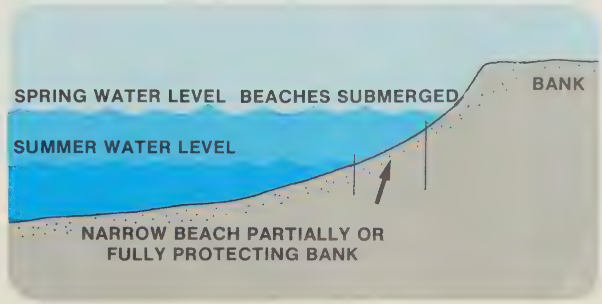
On tidal coasts,the wave attack on the shore cliffs usually occurs only at high tide. At low tide,the exposed tidal flats and the beach prevent the waves from reaching the cliff.



On the Great Lakes during periods of high water the effectiveness of existing beaches is greatly reduced and erosion rates escalate. During low water periods,the erosion rates decrease.



On the non-tidal section of the St. Lawrence, the beaches are defined by the lower summer levels. During the high spring levels,the beaches are generally completely inundated subjecting the banks to the action of waves and currents and most of the annual bank erosion occurs during that period.



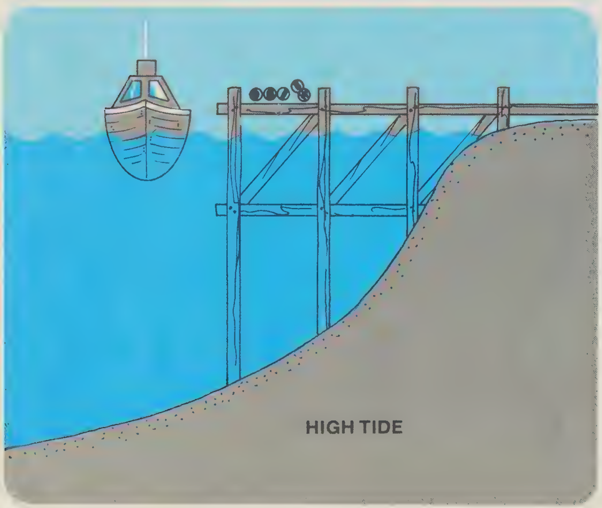
Water Level Fluctuations

Changes in water levels depend on astronomical, hydrological and meteorological conditions.

Water levels of sea coasts are influenced mainly by astronomical conditions (tides); the levels of inland bodies of water largely depend on hydrological conditions; and meteorological conditions affect both seacoast water levels and inland water levels.

Tides are the periodic rising and falling of sea levels produced by the gravitational pulls of the moon and sun. The moon's pull is about twice that of the sun's and the tidal rhythm, therefore, is dependent on the moon's rotation around the earth. The tidal range, that is, the difference in height between consecutive high and low waters, can vary substantially from day to day and month to month but at each location has a well defined pattern and is predictable on a long range basis. Large high and low tides called Spring tides occur when the gravitational pulls of the sun and moon act together. When the two pulls are out of phase with each other, smaller tides called Neap tides occur.

Generally, the tidal range on open coasts varies from 1-4 m. In some seas and gulfs, it can be significantly higher. For example, the Bay of Fundy regularly records tides in excess of 12 m. Large tidal ranges, in addition to exposing shores to wave attack, can also create currents strong enough to do considerable erosive damage.

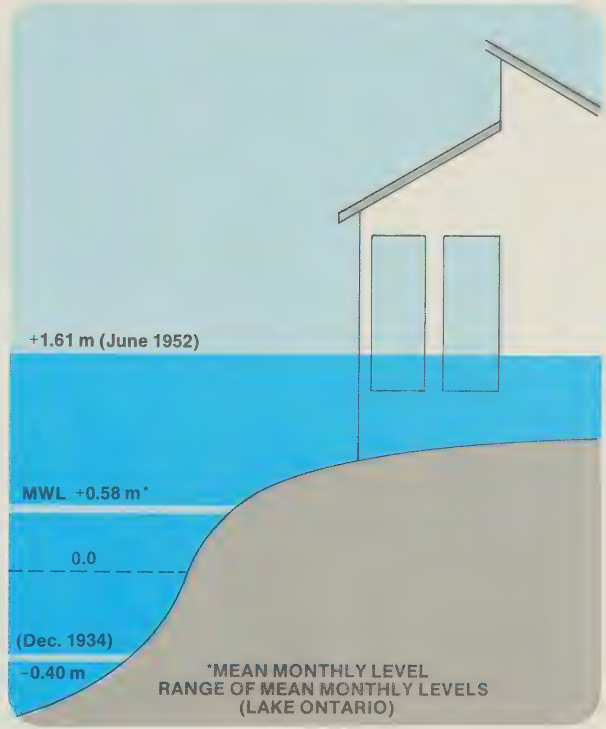


Hydrological Water Level Fluctuations (Non-Tidal)

Canada has some of the largest inland bodies of water in the world and changes in their water levels are the result of variations in the amount of precipitation, evaporation, runoff and their individual inflows and outflows.

Because of the dependence on hydrological and meteorological factors, the changes in level of inland waters are more or less random and the sequences and duration of high and low water periods cannot be predicted on a long term basis.

On the Great Lakes during the course of a year, seasonal changes in water levels occur with the lowest levels in winter and the highest during spring and summer. Depending on the particular body of water, seasonal changes can range from a few centimetres to about 2 metres.



St. Lawrence River (Non-Tidal)

On the non-tidal sections of the St. Lawrence River, the water levels in the river depend on the discharge and rate of flow. During the ice free season, the water levels depend only on the discharge of water from the Great Lakes. In winter, due to ice retardation of the flow rate, the levels are much higher. So, the variation of the levels within the year and from year to year, depends on discharge and ice condition.

Meteorological Water Level Fluctuations

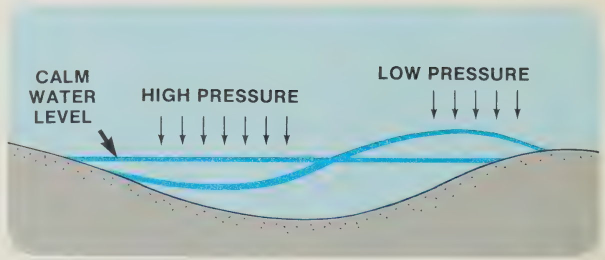
Two of the major meteorological conditions, which cause changes in water levels, are abnormal atmospheric pressures and strong winds.

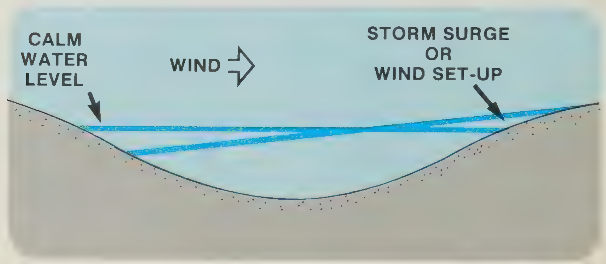
When extreme atmospheric pressures pass over enclosed bodies of water, waves called seiches occur. Seiches are similar to the sloshing oscillations that occur in an enclosed tank of water.

When very strong on-shore winds blow over water, it has the effect of piling up large amounts of water on the shore. In this way, wind set-ups or storm surges are created. The result is that water levels can be significantly raised and severe wave attack can occur at abnormal elevations along the shore.

On the sea coast, depending on location, storm surges can increase the water level over calm conditions by 0.5 to 2 metres and even more under exceptionally severe storms or hurricanes.

On the Great Lakes, the storm surges generally do not exceed 0.5 m, except on Lake Erie. On the central section of Lake Erie, storm surges can be of the order of .75 m, while at the east end (Buffalo, Fort Erie) and west end (Toledo, U.S.), they can reach 2 m.





Currents

A current may be defined as the flow of water in a definite direction. Currents can have a major influence on shore development by moving large amounts of eroded material either alongshore or offshore. The amount of material a current is able to move will depend on the speed of the current and the size of the material.

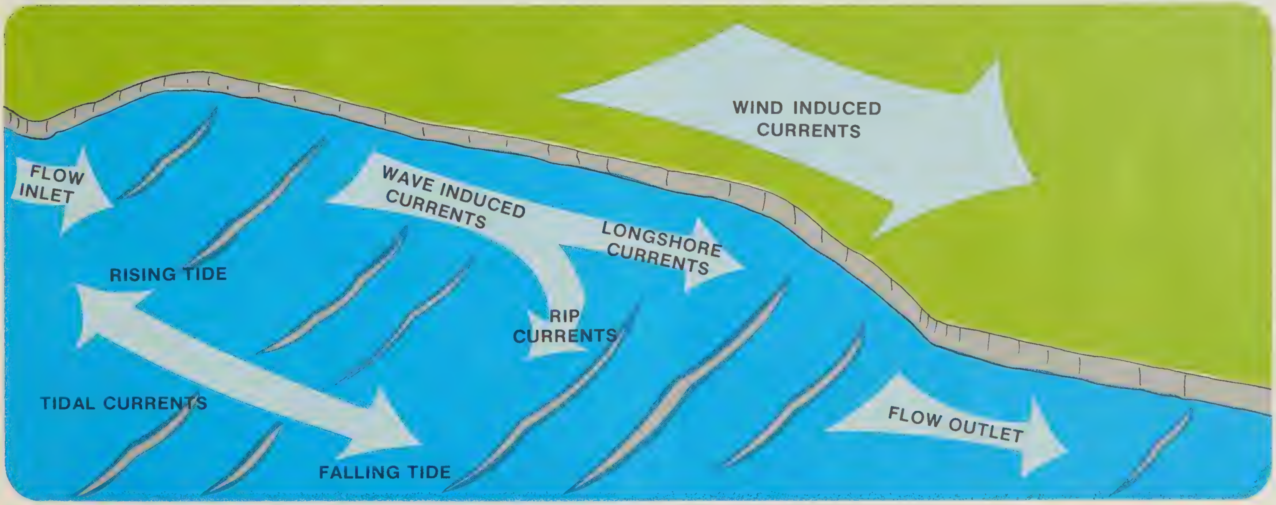
When waves approach the shore at an angle, the water forced against the shore will tend to flow in a relatively narrow strip parallel to the shore. This longshore current has the ability to move material suspended by wave action in the direction of the current. It can also, but to a much lesser degree, influence the movement of bottom material. Under certain conditions, longshore currents may turn offshore creating rip currents, thereby facilitating offshore movement of material.

Tides and storm surges also generate currents which may act with or against the wave generated currents increasing the variation of near-shore current strength and patterns.

Ice and Frost Action

On most Canadian inland bodies of water, as well as along our northern sea coasts, the presence of ice can have a profound effect on shore development. During winter, these shores may be completely covered with ice, thereby halting all erosive action. On the other hand, during spring and early summer when the breakup occurs, large chunks of floating ice can gouge or pile up on shores during heavy winds causing damage.

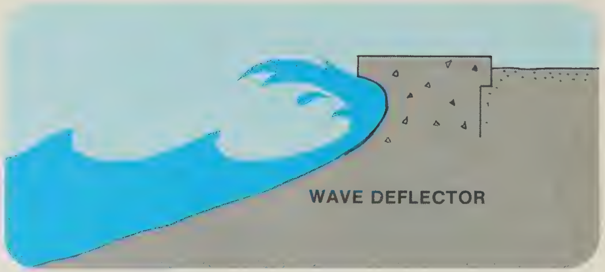
Frost action depends on alternating freezing and melting temperatures. When water which has penetrated the cracks and joints of rocks and other coastal formations freezes, it expands. This action can result in the breakup of material which can then be removed by waves and currents.



Shore Protection Works

Shore protection works consist of bank and beach protection works. The function of bank protection works is to protect the land and upland property from direct wave attack. The purpose of beach protection works is to trap or provide material from other sources to rebuild and stabilize beaches. Beach protection works can indirectly protect the bank.

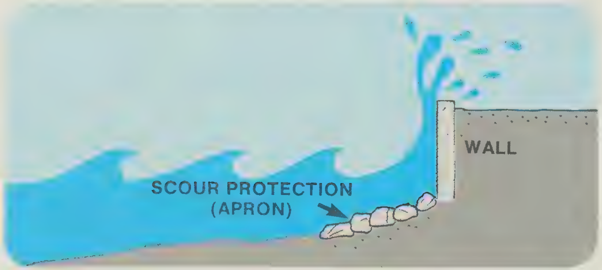
Shore protection works that gradually dissipate the wave attack, like sloping or stepped revetments are generally preferable to vertical walls that meet the sea head on. The force of wave impact on the structure or its components is much weaker in the first than in the second case, allowing the use of lighter or weaker and cheaper materials.

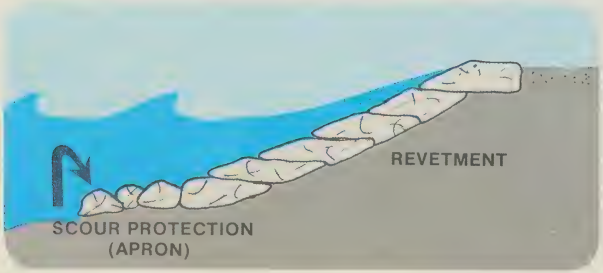


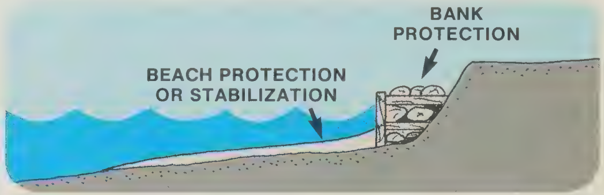
Bank Protection Works

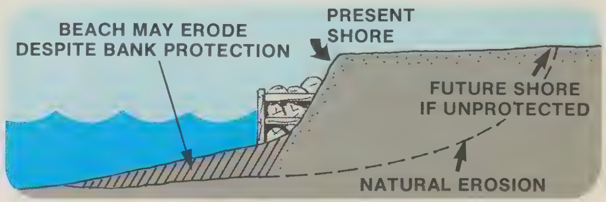
Bank protection works usually take the form of walls which may be vertical, curved, mound shaped or sloping structures. They may be constructed of stone masonry, concrete, steel or timber, depending on the desired shape, wave forces, availability of materials and the initial and maintenance costs.

Sloping or stepped bank protection works are preferable as they reduce the detrimental effects of wave reflection or downrush on the beach in front.



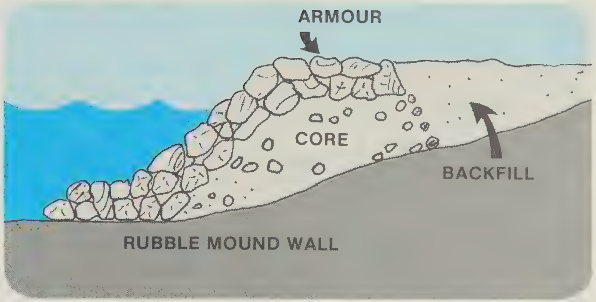


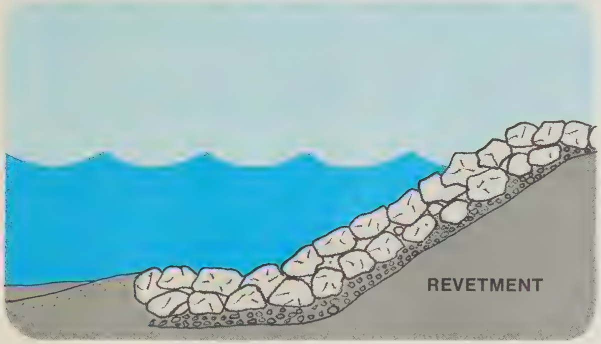




The curved and sloping structures are generally more effective against wave overtopping and spray than vertical walls.

Waves breaking against a vertical wall deflect both upwards and downwards. Normally a wave doubles in height as it strikes a vertical wall and unless the wall is high enough, overtopping or flooding may occur on the landward side of the wall. The downward deflection of the wave tends to scour the base of the wall. Material, such as rubble, is required at the toe to protect the wall foundation against undercutting.

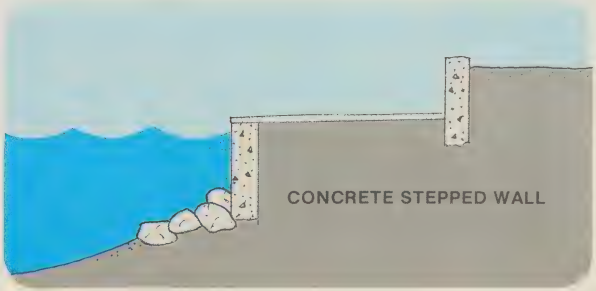




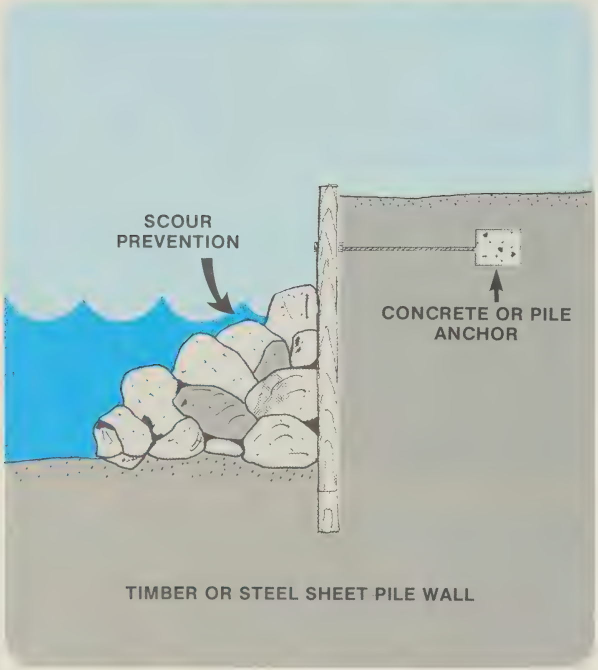
One of the most common shore protection structures is the rubblemound wall. This structure has a stone core covered with larger stones as protective armour layers. It absorbs wave energy, in contrast to other types of walls which reflect waves. The rubblemound wall is flexible in that it can follow the shoreline. It is, therefore, well suited for soft and irregular ground and where wave reflection is to be avoided.

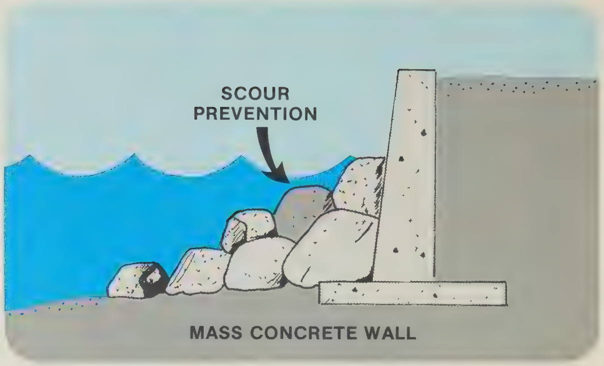
The size of stone and the thickness of armour cover required are dependent on the height of waves that can reach and break on the structure under storm conditions. The weight of individual stones in the armour is roughly proportional to the cube of the wave height. Durable stone that is not susceptible to frost splitting should be used.

In the construction of a rubble revetment, the toe of the slope should be protected with an apron to prevent scour.

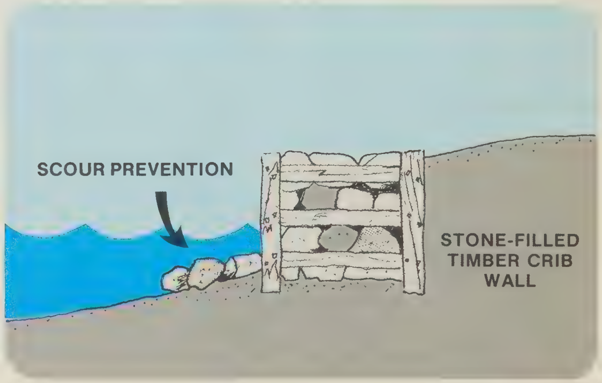


Steel or timber sheet piling can provide an effective bank protection under light wave attack. Under moderate to severe wave attack, an armour stone berm in front of the wall should be provided to protect the toe of the wall from scour and reduce wave reflection effects.





The protective ability of bank protection works is limited only to the land immediately behind them and not to adjacent areas up or downshore. Unless the shore protection is continuous or proper precautions taken, individual shore protection works can be outflanked. For this reason, joint action with neighbours is preferable to individual efforts.



Vertical or stepped gravity walls built of concrete or stone filled timber cribs are another form of bank protection. The same toe protection as for sheet pile walls should be provided.

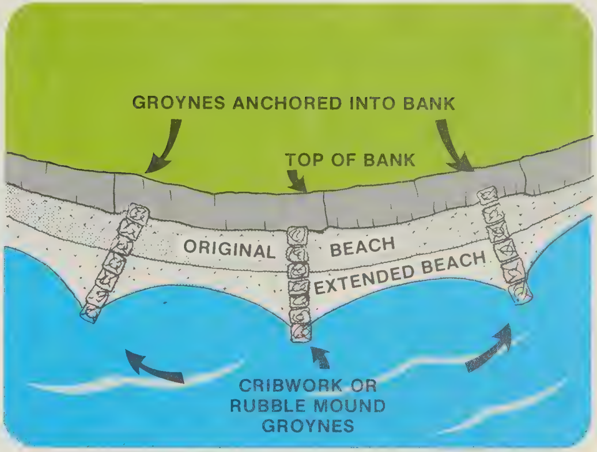
Beach Protection Works

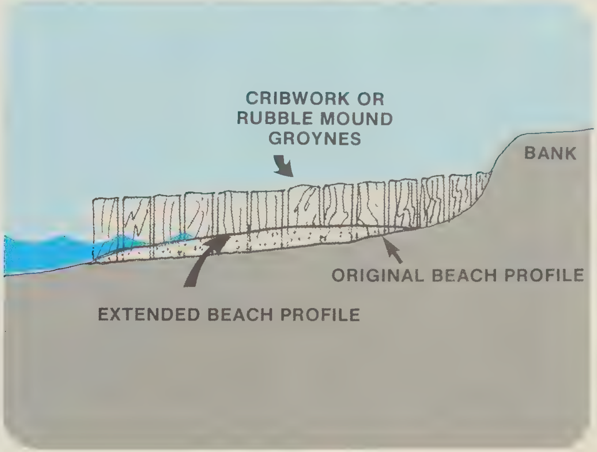
Beach protection works usually take the form of groynes, offshore breakwaters or beach nourishment.

Groynes are generally constructed perpendicular to the shoreline, across the beach and into the water, using timber, steel, concrete or rock. Usually, a series of groynes is constructed, their number depending upon the length of the shoreline to be covered. The function of groynes is to interrupt the movement of material alongshore and trap incoming material from the updrift side thereby enlarging the beach.

Groynes are most effective where large volumes of material are in transit.

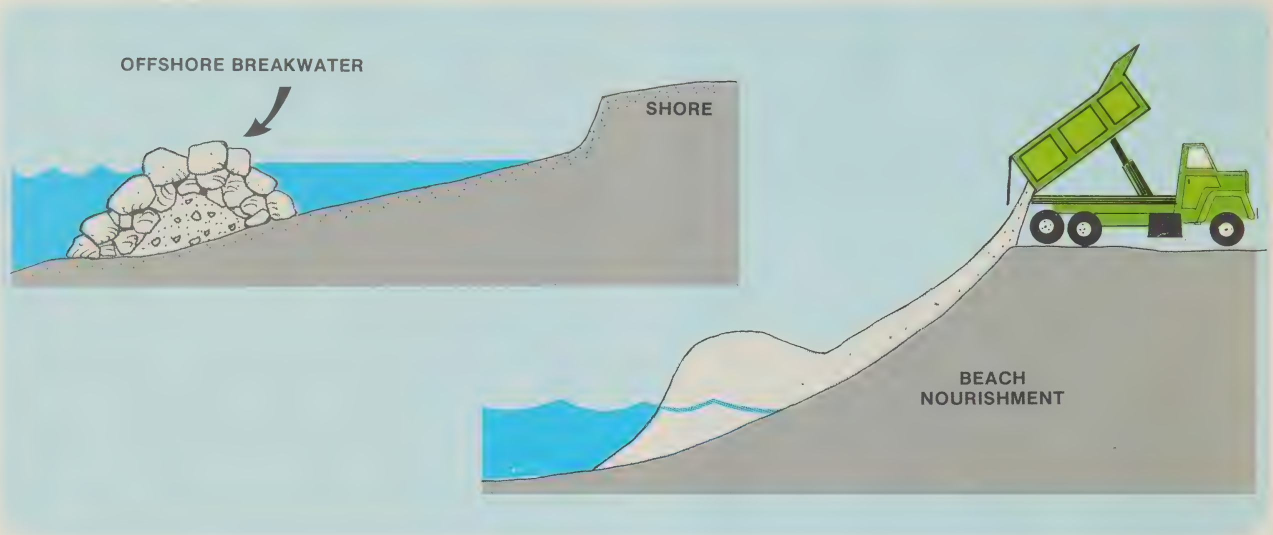
Long high groynes can adversely affect the down shore coast. Where drift is moderate or where down coast effects are to be minimized, low short groynes with bank protection and sometimes with a beach sill can be used. Their function is to stabilize the beach and reduce the wave attack on the beach or bank protection.





If the movement of material is onshore-offshore, one solution is to provide a barrier to wave energy and the movement of material offshore, such as an offshore breakwater. By reducing wave energy, an offshore breakwater traps alongshore drift, in addition to barring offshore movement of material.

Beach nourishment generally involves importing suitable material from borrow areas and feeding an eroding beach with the imported material. The type, composition, quantity, grading and placing of imported beach material play important roles in the effectiveness of beach nourishment and require detailed assessment.



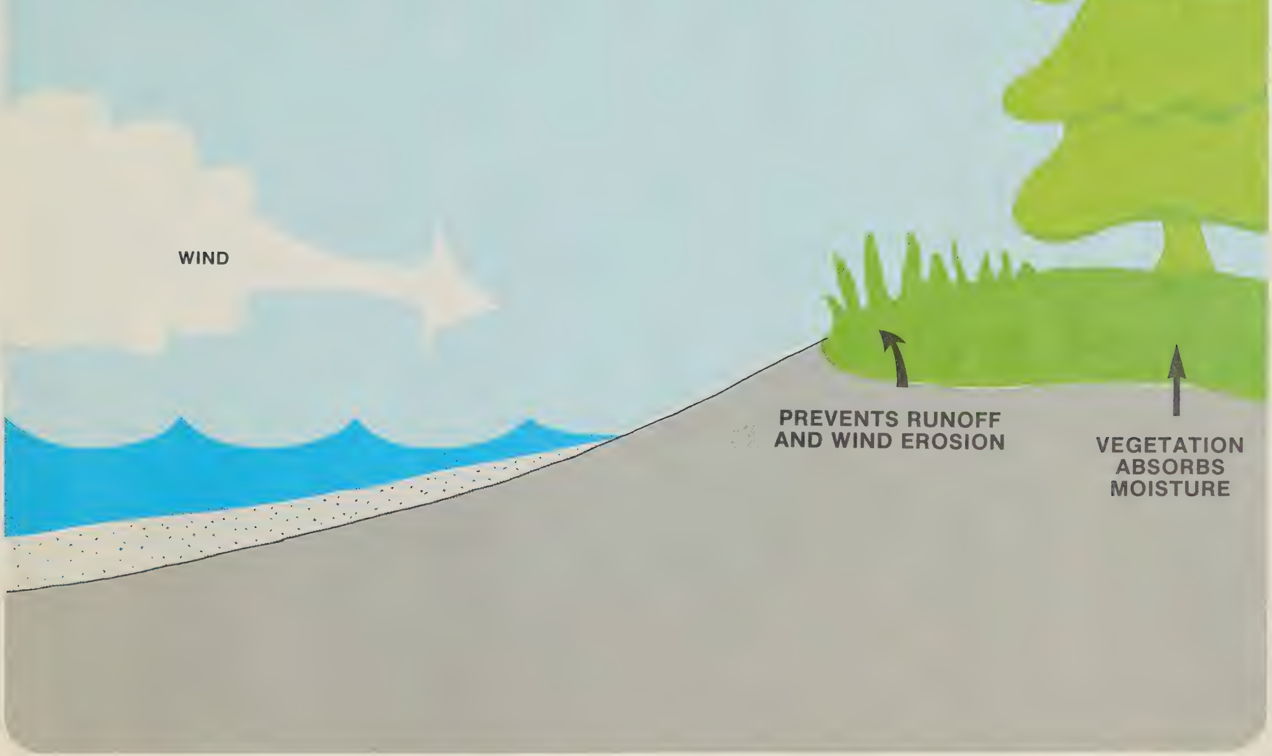
Offshore breakwaters are usually constructed using natural rock or stone or man made material.

Offshore breakwaters are constructed further out in the surf area and are, therefore, subject to more intense wave attack. As a result, they are quite massive, costly and generally not economically justifiable for private individual shore protection.

Beach nourishment may have to be repeated periodically. To reduce the frequency and volume of periodic re-nourishment, artificial beach feeding is often combined with beach stabilization works, like groynes, or a combination of low groynes and beach sills.

Vegetation

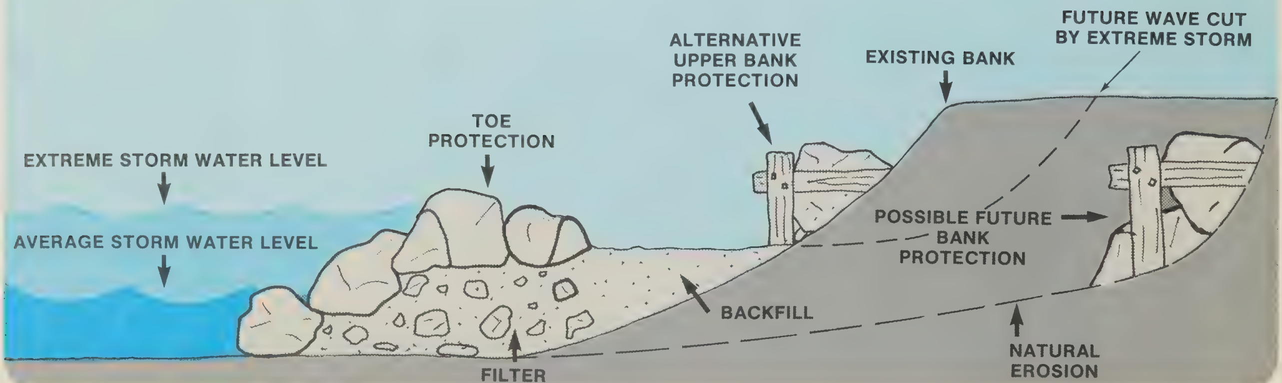
Vegetation not only improves the visual quality of a shoreline but can also provide protection to the beach shore slopes against rain and surface erosion and reduce frost penetration. It can also be used for dune stabilization and as a form of protection to low lands against surface erosion arising from storm water level inundation.



Toe Protection

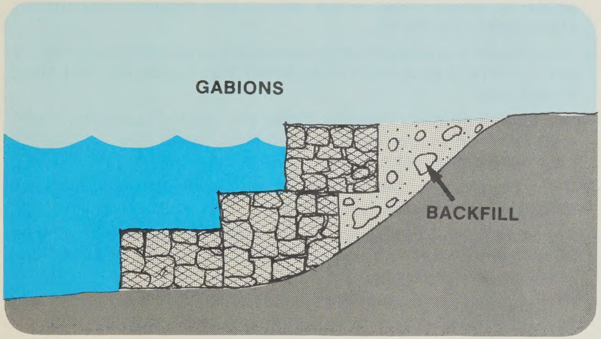
To avoid damage or complete loss of the structure, shore protection works are usually designed to withstand the wave attack under extreme storm conditions. Structures so designed may become quite costly and may be more massive and extensive then required to provide protection against the more frequent average storm.

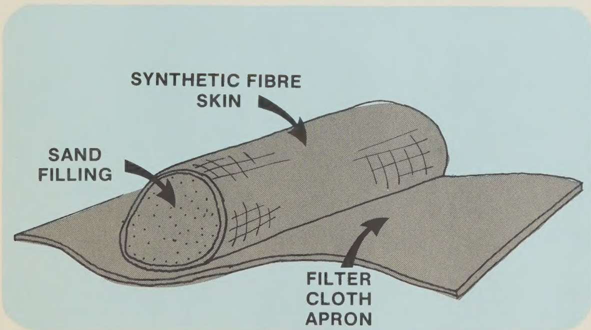
If extreme storm conditions are relatively rare occurrences at a particular location, it may be worthwhile to consider toe protection only and forgo the protection of the upper bank. This will arrest the erosion of the bank toe and stabilize the position of the beach. The upper bank will be cut back under extreme storm conditions, but if such events are rare, this process will take longer and the resultant damage loss less severe than in the absence of toe protection. Also, as the cut berm widens, the wave power reaching the bank will be attenuated and eventually equilibrium will be reached. If there are no buildings close to the bank slope, this may be a viable long term solution.



Selection & Planning

The severity and type of problem, ground and foundation conditions, type and range of water level fluctuations, cost and availability of local materials, and construction equipment and labour are major considerations in choosing the type of structure. The impact the structure would create on the adjoining shoreline must also be carefully evaluated. Joint action with neighbours may be more effective and economic, reduce the cost of expert advice and avoid outflanking by presenting a unified front to the sea.





Aside from the materials introduced under the structures already mentioned, there are several patented materials available in the market which are used in protection works. Some of these are: wire baskets, called gabions, which are filled with stone; wire bound precast concrete block mats; synthetic material forms which are filled with concrete and various kinds of bags and tubes which are filled with sand. In certain situations, these new forms may be cheaper and simpler to install than conventional forms of construction. However, since these new protective devices come in a limited range of component strength and size, their use may be limited to very specific exposure conditions and type of protective works. Expert advice on their use in a particular situation should be obtained.

General Hints

Improperly designed structures may cause excessive damage to adjacent property. Inadequately designed or constructed shore protection works may suffer serious damage or even be completely destroyed in a major storm, resulting in serious financial loss. So caution, understanding of local conditions, and expert advice are recommended.

When planning the construction of shore protection works:

— Check the long term natural erosion rates. A comparison of the original deed and present lot size may give an indication of the long term erosion rate and the magnitude of the problem.

— If there is no immediate emergency, postponing the construction and the expenditure by a few years may save money and give more time to obtain advice and information on the problem and best solution.

— If your property was partially protected in the past, examine any unprotected property adjacent to yours. The history of your own property may not reveal the true problem.

— Check the legal ownership of the beach or land on which you plan to build. The land that was once yours, but has been claimed by the water, may now belong to the Province and you may need a water or beach lot easement.

— Check for any Provincial or Municipal regulations concerning the construction of shore protection or assistance that may be available.

— See if your neighbours will be interested in a joint venture. It may save you money and avoid future disputes regarding adverse effects of your work on their property.

— Obtain all pertinent information on water levels and especially those that occurred during past major storms. People in the area may remember "how high the water came", the water level today may be deceptive. Water level records and tidal tables are available for many locations from Fisheries and Environment Canada, Marine Services Branch.

— Drive a few steel pickets into the beach in front of your property and observe changes in beach elevation. See how far it can go down after a major storm and how quickly it can be regenerated.

— Mark with a stake on your property how high the water comes after a major storm and note the date and any damage that occurs. The information may be useful to whoever designs the protection work.

— Check the price of local labour, materials and equipment rental costs. Check how the materials you propose to use fared when used by others in the area. It may give you an indication of how long you can expect them to last.

— Look at works constructed by others in the immediate area, especially those that came through a major storm. Find out how they survived, what damage occurred and how effective they were. Check if there was a noticeable shrinkage or expansion of beach since their construction.

— Do not "transplant" what appears to be a successful protective work without checking if the coastal environment at its location is similar to yours. What works well in one location may not be appropriate in another.

— Appearance is an important consideration in recreational property but in the final analysis, it is durability that counts, not what used to look good.

— See that all porous materials, stone, etc. used in the construction are placed on proper gravel or synthetic fabric filter, so that the base soil cannot leach out.

— If you respect your beach, avoid structures which are highly wave reflective (steep or vertical faces).

— The sand, gravel, cobbles or boulders on your beach were placed or left there by nature for a good purpose, so do not remove them. They may be hard to replace.

— In budgeting, allow for annual maintenance. Sea defenses should be kept in good repair. Waves seek weak spots and their attack is never ending.

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